Development of Product Configurators, Levels of Customisation

Jørgensen, Kaj Asbjørn

Published in:
Mass Customization Services

Publication date:
2008

Document Version
Accepted author manuscript, peer reviewed version

Citation for published version (APA):
Jørgensen, K. A. (2008). Development of Product Configurators, Levels of Customisation. In K. Edwards, T. Blecker, F. Salvador, L. Hvam, & G. Friedrich (Eds.), *Mass Customization Services* (pp. 277-289). Technical University of Denmark (DTU).

Presented at: IMCM&PETO2008 conference, 19.-20. June, 2008 in Copenhagen

Development of Product Configurators - Levels of Customisation

Kaj A. Jørgensen

Abstract

Product configuration is an approach for implementing *Mass Customisation (MC)*. With product configuration, each individual product is specified by configuration and the customer then makes decisions about the solution based on a set of available *options*. Typically, such options are presented by a *configurator*, which can support the customer in the configuration process. Hence, with such a configurator it is possible to configure multiple individual solutions – perhaps a large set of products.

When a configurator is designed, a large number of design parameters must be considered and balanced decisions must be made. In order to support this decision making, a *model for customisation* has been developed. This model arranges customisation in four different *levels of customisation,* ranging from the *structure level* at the bottom, through the *performance level* and the *value level* to the *learning level* at to top. The model has a dual view on customers at one side and products at the other side and it is developed so that configurator designers must decide how far up in levels the configurator should reach. A specific configurable building, the *Pregnant House*, is used as the case product.

Keywords

Product configuration, product family model, product configurator, customisation levels.

Introduction

Mass Customisation (MC) was initiated more than one decade ago as a research topic with Davis' publication "From Future Perfect: Mass Customisation" [Davis, 1989], presenting how products and services could be realised as a one-of-a-kind manufacture on a large scale. Davis also presented the idea that the customisation could be done at various points in the supply chain. In 1993, Pine published a major contribution to the mass customisation literature: "Mass Customization: The new Frontier in Business Competition" [Pine, 1993], [Pine et al., 1993], which was an extensive study of how American enterprises during the seventies and eighties had been overrun by the efficient Japanese manufacturers, which could produce at lower costs and higher quality. Since its introduction, MC has called for a change of paradigm in manufacturing and several companies have recognised the need for mass customisation. Much effort has been put into identifying, which success factors are critical for an MC implementation and how different types of companies may benefit from it [Lampel and Mintzberg, 1996], [Gilmore and Pine, 1997], [Sabin, 1998], [Silveira et al., 2001], [Berman, 2002].

For obvious reasons, there are different strategies on how to implement MC most appropriately and it varies naturally also between different companies, markets and products. Because there is not a single generic strategy, it is important to look at the issue from different viewpoints. The fact that products must be easily customisable in order to achieve MC has been described comprehensively in the literature. [Berman, 2002] and [Pine, 1993] proposed that the use of modular product design combined with postponement of product differentiation would be an enabler to a successful MC implementation. This issue of course also relates to the question of readiness of the value chain.

Mass Customisation and Product Configuration

An often used approach for implementation of MC is *product configuration*, in which a series of products is defined by one single model – a product family model (see figure 1) [Jørgensen, 2003]. Hence, a *product family* can be viewed as the set end products, which can be formed by combining a predefined set of modules [Faltings, 1998], [Jørgensen, 2003]. In the product family model, it is described, which modules are included in the product family model and how they can be combined. The result of each configuration will be a model of the configured product, *configured product model*. From this model, the physical product can be produced (see figure 1).

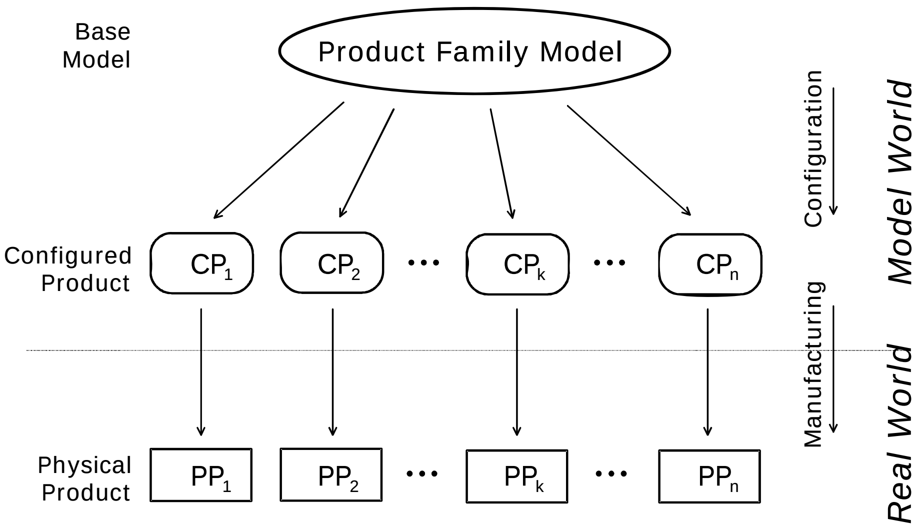

Figure 1 – Product family model as basis for configuration

From time to time, several different methods for defining product family models and product configurators have been proposed, each with their own advantages. A “Procedure for building product models” is described in [Hvam, 1999] based on [Hvam, 1994]. It is a rather practical approach with a seven step procedure, describing how to build a configuration system from process analysis and product analysis onto implementation and maintenance. For the product modelling purpose it uses the Product variant master method followed by object-oriented modelling to describe both classification and composition in a product family. The object-oriented approach is also applied by [Felfernig et al., 2001], who uses the Unified Modelling Language (UML) to describe a product family. This is done by using a UML meta model architecture, which can be automatically translated into an executable logical architecture. In contrast to [Hvam, 1999] this method focuses more on formulating the object-oriented product structure, rules and constraints most efficiently. The method also focuses on how the customers’ functional requirements can be translated into a selection of specific modules in the product family.

A product family model is often the basis for development of a product configurator. A *product configurator* can be defined as a tool, computer software, which can support users in the configuration process [Faltings, 1998], for instance by selecting modules to compose products. Hence, with a product configurator, it is possible to configure multiple individual solutions – perhaps a large set of products.

Application of Product Configuration

Mass Customisation and product configuration is relevant for many enterprises and great benefits are normally found, where customisation is common and where the idea is introduced gradually. In general, however, the benefits depend very much on the product and the market. In the relationship between the manufacturer and the market or more precisely the product and the customer, the product configurator plays a major role.

A major distinction regarding markets/customers is between business-to-business (B2B) and business-to-consumers (B2C) and an important dimension here is the *degree of personalisation*. Personalisation is most relevant in relationship with B2C and a high degree of personalisation towards individual customers or small groups of customers generates special requirements to product configurators but, on the other hand, this also raises new opportunities for increased volume.

Development of computer based configurators provides a range of opportunities for adding new dimensions to the subject and configuration may also *add more value to customers*. Therefore, when a configurator is designed, a large number of design parameters must be considered and balanced decisions must be made. Many of the parameters are related to development of software systems, e.g. usability, reliability, flexibility and security. Some of these parameters will not be considered in detail in this paper. The primary focus will be on relationship between market/customer and the product and a new model with identification of customisation levels is developed and presented in the following.

Customisation Levels

Most of the methods, which exist for product family modelling, focus on modelling of the solution space of a configuration process. This means that they describe the possible attributes of the products and the product structure. Hence they do typically not focus on additional information which goes beyond, what must be used to perform the configuration itself. This kind of information, which could include e.g. customer, market, logistics and manufacturing information, is according to [Reichwald et al., 2000] similarly important, since a successful implementation of MC must integrate all information flows in the so called "Information Cycle of Mass Customisation".

In order to support the decision making regarding customisation of products, the following *model for customisation* has been developed (see figure 2). This model arranges customisation in four different *levels of customisation,* ranging from the *structure level* at the bottom, through the *performance level* and the *value level* to the *learning level* at to top. The model has a dual view on customers at one side and products at the other side and it is developed so that configurator designers must decide how far up in levels the configurator should reach.

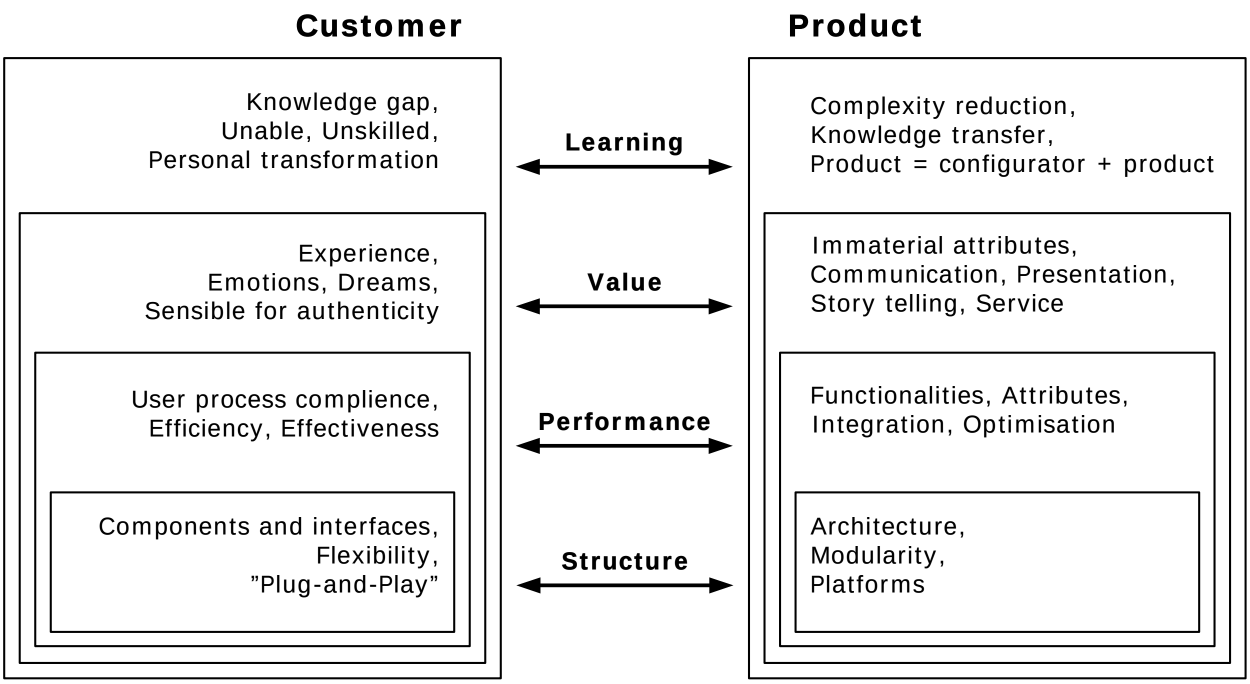

Figure 2 – Customisation on four different levels

Customisation: Structure Level

Configuration on the structure level is a rather common view of configuration and is characterised as a matter of acquiring components, which can be used as building blocks – the well known LEGO bricks. Important issues are modularity, interfaces of modules and product platforms. Modules are defined as assemblies of components and end products are composed of modules (see figure 3). Very often, modularity is recommended as a precondition for implementation of product configuration and modules are most preferably identified with clear separation of functionalities, i.e. modularity is in contrast to integration. Further, different architectures of modularity are worth considering.

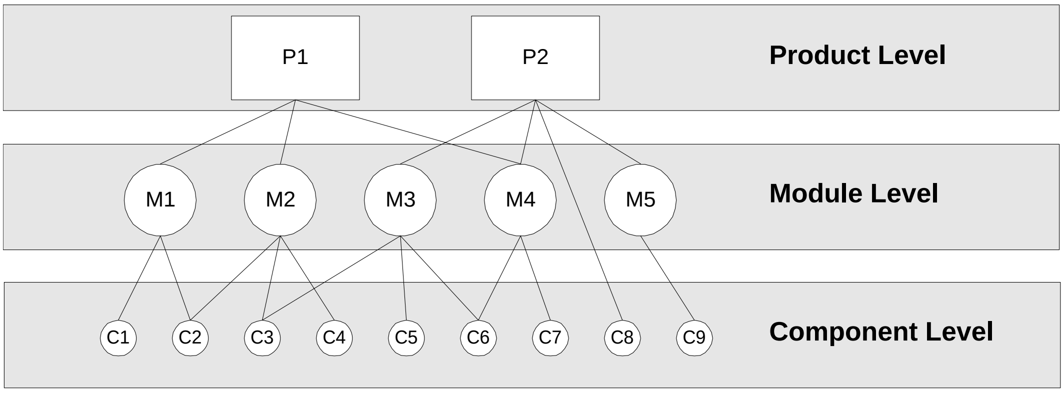

Figure 3 – Model of the structure with the three levels.

Customisation: Performance Level

On the next level, the performance of products is essential. When products are installed in their user environment, they perform their functions – hopefully in the expected way. Therefore, considerations about the ability to perform the functions, which are required by the customer, are very important and should be a significant subject of configuration. Hence, the focus of product configuration is shifted to identification and definition of product attributes instead of modules and components. This is particularly important in companies, where order horizons are long and where many changes often have to be managed.

Figure 4 gives an overview of how underlying modules/components of an end-product in a product family can be determined on the basis of decisions regarding attributes.

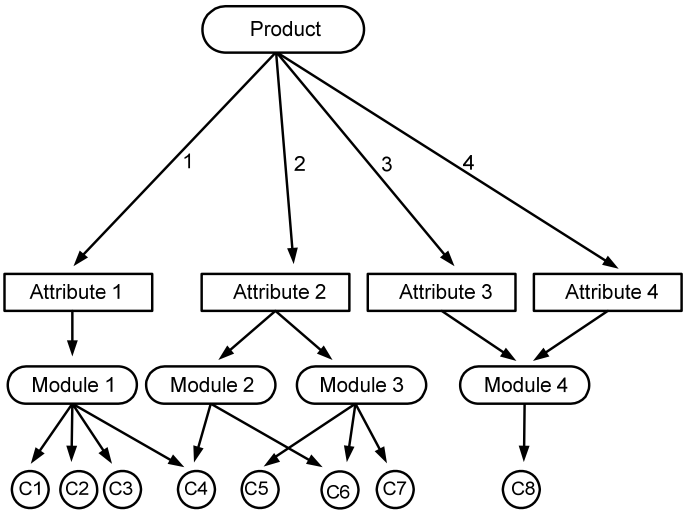

Figure 4 – Specification of modules directly or indirectly through functionalities.

Attribute 1 corresponds to one module whereas attribute 2 determines two modules. Further, the figure shows that module 4 is determined by two attributes.

In special situations, products are units, which are not composed of multiple modules, e.g. parametric products, services and software products. In such cases, the end-product is defined by adjusting a set of parameters.

Mapping of functional requirements to specific modules is considered in [Jiao et al., 1998], [Du et al., 2000] and [Männistö, 2001]. Jiao proposes to use a triple-view representation scheme. The three views are the functional, the technical and structural view. The functional view is used to describe, typically the customer's functional requirements and the technical view is used to describe the design parameters in the physical domain. The structural view, which corresponds to the structural level described above, includes the mapping between the functional and technical view as well as the rules of how a product may be configured. The description of this modelling approach is however rather conceptual, and does not easily implement in common configuration tools.

The two lower levels of customisation, the structure level and the performance level, are rather common and widely used with many products and on all types of markets. Further levels of customisation will primarily relate to customers and products with higher degree of personalisation.

Customisation: Value Level

The next level, the value level, focuses on special attributes of products and also on *immaterial attributes*, which are related to customer *emotions* and *dreams*. Involvement in a configuration process will for many customers result in a higher degree of *satisfaction* and the customer will likely feel a stronger attachment to the solution [Pine and Gilmore, 1999]. The value level of customisation is therefore strongly related to personalisation. Hence, customers are primarily individual persons or relatively small groups. Many fashion and service products, for instance, are highly personalised and aim at giving the customer specific experiences. Examples are entertainment, personal care, wellness and travel. Many examples show that configurators for these types of products aim at special values of the products for the customers. But for many customers, ordinary products may be looked at with extra dimensions of personal valuation. Customer's concern for the environment may for instance give more preference for ecologic products.

Because the value level focuses primarily on attributes, Figure 4 can also be used as an illustration of this case. In order to create good support for the value level, it is important that the available options are matched properly with the customer needs and it is important to analyse, what effect different attributes have on customers, whether they are real or imaginary attributes. Many products are presented with images of apparently happy people and admirable locations.

An important aspect of this customisation level is authenticity [Gilmore and Pine, 2007]. There is a tendency that customers are becoming more sensitive and expect higher and higher quality of goods and services. Practically all consumers desire authenticity. Every person is unique and intimately aware of and valuing his own uniqueness. The consumer sensibility for authenticity evidences itself whenever informed individuals independently purchase any item with which they are intensely involved. According to this theory, many companies fail if they act differently than they announce that they do. In such cases, there may be a great risk that configuration will give a negative effect. If a company claims to be very conscientious, it may very fast loose great respect, if it is disclosed that some products for instance are produced by children and perhaps under poor circumstances.

Means for good configurator support on the value customisation level are to present the perhaps unseen values of products and to provide good and reliable guidance to the user, to display consequences of choices. If the options are limited, it is important to be selective regarding customer segments. However, some customers may be intimidated by getting a wrong message. In many cases it is like balancing on a knife edge; if you fall, you may cut yourself.

Customisation: Learning Level

At the top level of customisation, the learning level, the configurator offers services that may result in further impact on the involved customer. At this level, *the transformation of the customer* is the primary aim. A primary product is available but special aspects of the product lead to a learning process with the customer. Consequently, a further amount of services are added and such services may include a range of subjects that represent a gap between the customer's knowledge and what the product can offer. The lower customisation levels may be identified, i.e. a modular or otherwise configurable product is offered and appealing attributes can be presented, but addition of the learning level can create further attraction from the customer towards the underlying product.

The customer's knowledge gap may be related to different areas. The product may be complex and difficult to understand and assess or it may be difficult for the customer to estimate, how the product can fulfil the requirements. Perhaps the product must fit into complex processes at the customer's site. Maybe the customer is a first time buyer so many issues are new for the customer. Therefore, it should be possible for the customer to find answers to questions about issues, which the customer finds complex. If customers are unable or unskilled to make decisions about such issues, the configurator must include trustworthy guidance. In this way, the configurator is integrated with the product or it can be seen as a part of the product.

Like for the previous presented customisation levels, adding such additional features also requires a good segmentation of customers in order not to give a negative effect. Well skilled customers may find this kind of support as a barrier, so it is important that the configurator is able to adjust itself to different customers.

Product Case: Pregnant House

In this paper, product configuration is primarily aimed at *configuration of buildings*, i.e. buildings are in this situation regarded as the products. A specific configurable apartment building, the *Pregnant House*, is used as the case product. The Pregnant House building is extensible and the name pregnant refers to the occasion that, if the family gets pregnant, the house can also get "pregnant".

Customers will be able to select a variety of configurations and also to some degree participate in design of certain solutions. The customers of apartment buildings are typically individuals or families.

Application of configuration to building construction is well known, but development of computer based configurators provides a range of opportunities for adding new dimensions to the subject and configuration may also *add more value to customers*.

The Pregnant House has many qualities and possibilities and embraces the best of different types of apartments. It has a unique architecture but, on the other hand, it also supports the demand for individual solutions.

Pregnant House is configurable in multiple ways. The primary architecture includes a ground floor with the possibility to add a tower, which can be one or two stories high (see figure 5). In addition, the width and position of the windows can be changed within some limitations. By this flexibility, Pregnant House offers special possibilities to bring light from the exterior into the rooms.

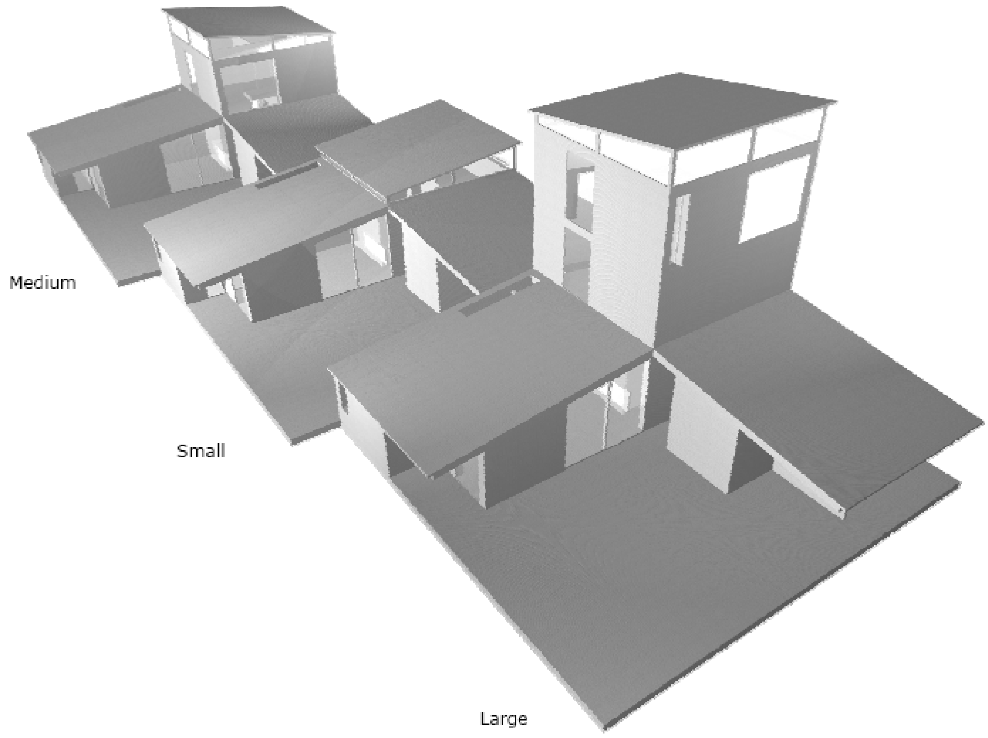

Figure 5 – Three different configurations of Pregnant House

At the facades, it is the intention to offer a range of different materials which, thereby, creates a variety in architecture even though the configurations are standardised. Internally, it is possible to make a number of arrangements of rooms and equipment of rooms (see figure 6). The number of rooms can be selected and rooms can have different size. More over, it is the intention also to add some limited possibilities for customers to design certain details.

With these configuration possibilities, it is the aim with Pregnant House to offer attractive apartment buildings, which can satisfy a larger number of individual needs compared to traditional building types. Especially, the flexibility adds great value to Pregnant House because possible extensions of the building are planed in advance. A consequence of this is that it is possible to have such extensions prepared and ready for economic manufacturing.

Figure 6 – Different arrangement of rooms on the ground floor of Pregnant House

Pregnant House Configuration

The Pregnant House case is ideal because there are a reasonable large number of configuration options and it is possible to illustrate all levels of customisation. Apartment houses relate to the B2C market and, as mentioned, the typical customers are individuals or small groups like families. Hence, a considerable degree of personalisation is also present.

The structure level of customisation relates to the organisation of construction components and, in fact, it is the intention to prepare the Pregnant House for industrial manufacturing. Many design issues has been related to the division of the building in order to get the most appropriate sections for manufacturing, transportation, assembly, etc. In addition, each section may be configured differently prior to the manufacturing. These configurations cover a number of areas like room arrangement, selection of interior, selection of coverings, selection of colours and selection of various building services. Segmentation of the building includes special development of assembly components and methods.

At the performance level, a number of attributes can be identified in response to the customer needs. These attributes include the size of the living space, the selection of types of rooms, the size of the rooms, the orientation of the building on a given site, the arrangement of windows and how it is drawing light from outside into the rooms. If customers, in accordance with the model for customisation (figure 2), focus on these attributes, it will be possible to generate automatically the selection of modules of the building. The customers do not need to know about the segments and will expect that the underlying structure is unified and optimised.

At the value level, a number of issues are also relevant. First of all, the thoroughly prepared architecture should make strong appeal to many customers and should support the creation of good bonds between the customer and the product. Secondly, the well planed options for extending the building should draw significant attention. In addition, it should be valuable for many customers that it is possible to specify a large number of different configurations without substantial increase of cost. Further attributes includes quality, usability, maintainability, serviceability, etc. Normally, the location of the building is a very important attribute, but this is considered out of scope of this project.

At the learning level, the Pregnant House project has also a number of excellent examples. A building is in many ways a complex product, which can be difficult to manage in an optimal way. Especially for customers, who are buying or renting for the first time, a number of issues may be complicated to understand and to decide about. A number of authorities have requirements and regulations about buildings, so what are the constraints and what rights does the owner or the tenant have? Operation and maintenance of buildings must be performed adequately, but there are many alternative methods and it may be difficult to choose an appropriate solution. Financing may also be complicated and in order to develop budgets it may be difficult to calculate economic estimates regarding e.g. heating expenses, maintenance expenses, financial payments, tax payments, etc. Support for customisation on this level must include the possibility to be guided sufficiently about such issues and many potential customers may learn from it. However, it is important that it is presented as extra features, which may be used on demand. No doubt such features may attract and appeal to certain customers but may be irrelevant for others.

Based on the model for customisation and the identified levels in relationship with Pregnant House, a development of a configurator has been initiated. As part of the development approach, a product family model (see figure 1) is structured by following the ideas presented in [Jørgensen 2006]. The model will be independent on any development tool and differs some from the approach described in [Hvam 1999]. The primary content is the identified set of model component types and the identification of these types is performed by classification and related to each other in a hierarchical structure - the taxonomy. Relations about the structure are modelled afterwards. The model component types include the different types of rooms and the types of building components but also component types available for description of the customers. When this model is completed and the user interface is designed, the detailed development of the configurator can be performed.

Conclusion

Implementation of Mass Customisation (MC) by using product configuration provides the possibility that each individual product is specified by a configuration process, where customers make decisions about the solution based on a set of available *options*. It is thereby possible to configure multiple individual solutions.

Product configuration can be applied to many products and many markets or customers and the development of configurators will depend on these application areas. A major distinction regarding markets/customers is between business-to-business (B2B) and business-to-consumers (B2C). An important dimension here is the degree of personalisation because a high degree of personalisation towards individual customers or small groups of customers generates special requirements to product configurators. Implementation of such requirements, however, may also raise new opportunities for increased volume.

Development of configurators, which can offer a good support for configuration processes and produce well specified individual product models, is a great challenge and, when a configurator is designed, a large number of design parameters must be considered and balanced decisions must be made. In order to support this decision making, a model for customisation has been developed and presented above. The model arranges customisation in four different levels of customisation, ranging from the structure level at the bottom, through the performance level and the value level to the learning level at to top. The model includes a dual view on customers at one side and products at the other side. Designers must decide how far up in levels the configurator should reach.

In this paper, product configuration is primarily aimed at configuration of buildings, where the customers typically are individuals or families. A specific configurable building, the Pregnant House, is used as the case product. Customers will be able to select a variety of configurations and thereby to some degree participate in design. Application of configuration to building construction is well known, but development of computer based configurators provides a range of opportunities for adding new dimensions to the subject. With specific address to the Pregnant House case, it is argued that the presented model for customisation on different levels can add more value to a product and make it more attractive for customers to select.

References

[Berman, 2002]
Berman, B. (2002). Should your firm adopt a mass customization strategy? Business Horizons, 45(4):51–60.

[Davis, 1989]
Davis, S. (1989). From future perfect: Mass customizing. Planning Review.

[Du et al., 2000]
Du, X., Jiao, J., and Tseng, M. M. (2000). Architecture of product family for mass customization. In Proceedings of the 2000 IEEE International Conference on Management of Innovation and Technology.

[Faltings, 1998]
Boi Faltings and Eugene C. Freuder (Ed.): *Configuration - Getting it right.* Special issue of *IEEE Intelligent Systems*. Vol.13, No. 4, July/August 1998.

[Gilmore and Pine, 1997]
Gilmore, J. and Pine, J. (1997). *The four faces of mass customization.* Harvard Business Review 75 (1).

[Gilmore and Pine, 2007]
Gilmore, J. and Pine, J. (2007). *Authenticity*. Harvard Business School Press.

[Hvam, 1999]
Hvam, L. (1999). A procedure for building product models. Robotics and Computer-Integrated Manufacturing, 15:77–87.

[Jiao et al., 1998]
Jiao, J., Tseng, M. M., Duffy, V. G., and Lin, F. (1998). Product family modeling for mass customization. Computers & Industrial Engineering, 35:495–198.

[Jørgensen 2003]
Kaj A. Jørgensen: *Information Models Representing Product Families*. Proceedings of 6th Workshop on Product Structuring, 23rd and 24th January 2003, Technical University of Denmark, Dept. of Mechanical Engineering.

[Jørgensen 2006]
Kaj A. Jørgensen: *Product Modelling on Multiple Abstraction Levels*. In: Mass Customization, Challenges and Solutions, pp. 63-84, Springer Verlag, 2006.

[Lampel and Mintzberg, 1996]
Lampel, J. and Mintzberg, H. (1996). Customizing customization. Sloan Management Review, 38:21–30.

[Männistö, 2001]
T. Männistö, H. Peltonen, T. Soininen and R. Sulonen: *Multiple Abstraction Levels in Modelling Product Structures.* Data and Knowledge Engineering no.36, pp.55-78, 2001.

[Pine, 1993]
B. Joseph Pine: *Mass Customization - The New Frontier in Business Competition.* Harvard Business School Press, Boston Massachusetts, 1993.

[Pine et al., 1993]
Pine, J., Victor, B., and Boyton, A. (1993). *Making mass customization work.* Harvard Business Review 71 (5), 71(5):108–119.

[Pine and Gilmore, 1999]
Pine, J. and Gilmore, J. (1999). *The Experience Econmy : Work Is Theater & Every Business a Stage*.

[Reichwald et al., 2000]
Reichwald, R., Piller, F. T., and M¨oslein, K. (2000). Information as a critical succes factor or: Why even a customized shoe not always fits. In Proceedings Administrative Sciences Association of Canada, International Federation of Scholarly Associations of Management 2000 Conference.

[Sabin, 1998]
D. Sabin and R. Weigel: Product Configuration Frameworks - A survey. In IEEE intelligent systems & their appplications, 13(4):42-49, 1998.

[Silveira et al., 2001]
Silveira, G. D., Borenstein, D., and Fogliatto, F. S. (2001). Mass customization: Literature review and research directions. Int. Journal of Production Economics, 72:1–13.